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RESEARCH ARTICLE

Shelf life and proximate composition of tomato (*Solanum lycopersicum* L.) fruits as influenced by storage methods

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Abstract: Tomato (*Solanum lycopersicum* L.) is a perishable fruit with a relatively short shelf life. The quality and nutritional value of fresh produce like tomato are affected by postharvest handling and storage conditions. This work aimed at evaluating the effects of storage methods on the shelf life and proximate composition of four varieties of local (Hausa and Yoruba Nigeran land races) and improved (Tropimech and Roma VF) tomato. The mature green fruits of each variety were manually harvested and stored. Three storage structures were employed *viz.,* plastic crate, raffia basket and pot-in-pot refrigerator. Three botanical preservatives (plant byproducts) were used *viz.,* wood ash from shea butter tree (*Vitellaria paradoxa*), sawdust from African mahogany (*Khaya ivorensis*) and rice (*Oryza sativa*) straw. Each preservative was mixed with each variety of tomatoes in 1:2 ratios (1.75 kg of preservative to 3.50 kg of fruits) in each storage device. Shelf life was determined when more than 50% of fruits showed symptoms of shrinkage or spoilage (fruit rot). Proximate analysis was carried out for the amounts of moisture, ash, crude fibre, crude protein, crude lipid and carbohydrate in the stored fruits. Shelf life of all the varieties was enhanced by pot-in-pot refrigerator. Proximate analysis revealed that moisture was highest, followed by carbohydrate in all varieties irrespective of storage structure and preservative. The improved varieties showed higher values of all the proximate parameters when compared to the two local varieties (Hausa and Yoruba).Out of the storage structures, pot-in-pot refrigerator seems to be more suitable to enhance shelf life of tomato fruits without compromising its quality.

Keywords: Pot-in-pot Refrigerator, Preservative, Rice Straw, Sawdust, Storage Period.

INTRODUCTION

Tomato, *Solanum lycopersicum* L. (Solanaceae) is native to South America, especially Peru and the Galapagos Island (Mattew, 2011). Peralta and Spooner (2007) reported that the origin of tomato was traced to Peru and Mexico. Tomato is rich in protein with a trace amount of fat (Olaniyi *et al*., 2010) and also contains many vitamins and minerals that ensure good health. It is an excellent source of vitamins B6, ascorbic acid, and niacin and minerals that function as cofactors in enzymatic activities (Nour *et al*., 2013; Luthria *et al*., 2006).

Tomato is the second most important vegetable worldwide after potato (Dorais *et al*., 2008). Environmental factors such as soil type, temperature, frost and rainy weather can have an adverse effect on storage life and quality of fruits and vegetables (Bachmann and Earles, 2000). Fully ripe tomato fruits can be stored at 2 - 5 ^{o}C for few days to avoid chilling injury (Passam *et al*., 2007). The unpleasant aroma of fruit stored at 5^{o}C is caused by the loss of the principal volatile compounds detected by gas chromatography (Maul *et al.*, 2000). Enzymatic changes occurring during ripening also determines the changes in the flavour and aroma constituents of the fruits (Krumbein *et al.,* 2004). However, ripening and shelf life of tomato fruits can be delayed by an enclosure of tomato fruits in polyethylene or other forms of plastic packaging materials (Srinivasa *et al.,* 2006).

Tomato fruits, generally, are succulent and perishable and as a result, have a short shelf life. Good and protective storage methods are required to enhance their shelf life as well as their physical qualities (Saeed *et al*., 2010). Tomato fruits need to be harvested at green mature stage following the recommendation of (Anju-Kumari *et al*., 1993) that the longest shelf life of tomato cultivars can only be achieved when the fruits are harvested at this stage.

The shelf life of fruits can be improved by low temperature, 90% humidity, removal of ethylene production, stored in 5% Carbon IV Oxide, use of chemicals and irradiation (Shaun and Ferris, 1997). One way of prolonging the shelf life of tomato in tropics is the use of moist sawdust (Kapsiya *et al*., 2015). The sawdust from different wood species has different potential to absorb and retain water mainly due to the differences in composition (Johnson and Hodari-Okae, 1999). There may also be differences in the microorganisms which would infect stored tomato treated with the preservatives (Johnson and Hodari-Okae, 1999). Wood ash possesses insecticidal and antifungal properties (Aborisade, 2003). Earthenware pot had been used for the storage of fruits and vegetables (Akomolafe and Aborisade, 2007).

Conditions at storage sometimes lead to loss of nutritional quality of the fruits (Gil *et al*., 2006). During

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storage, there are certain biosynthetic pathways that contribute to the development of organoleptic qualities of fruits. Further, poor handling and improper postharvest treatments contribute largely to postharvest losses by reducing the shelf life and affecting the nutritional quality of fruits. This work aimed at evaluating the synergy between the nature of storage structures and botanical preservatives on the shelf life and proximate composition of four varieties of tomato fruits.

MATERIALS AND METHODS

Collection of fruits

The seeds of two local varieties (Hausa and Yoruba Nigerian land races) and two improved varieties (Tropimech and Roma VF) were planted in a farm located at Lasoju along Ilorin-Ogbomosho Express Road, Ilorin. After maturity, the mature green fruits of each variety were harvested, collected into sterile raffia baskets and taken to the Plant Biology Laboratory, University of Ilorin, Ilorin, Nigeria. Each variety was designated as V1 = Hausa, V2 = Yoruba, V3 = Tropimech and V4 = Roma VF.

Storage Methods

Freshly harvested fruits of each variety were sorted to eliminate damaged/diseased ones. The fruits were surface sterilized with 70% ethanol and rinsed with sterile distilled water. Three (3) storage structures were employed *viz.,* plastic crate, raffia basket and pot-in-pot refrigerator. The plastic crates used had cuboid shape with dimension 37×24×20cm (length × width × height). The average diameter and height of the raffia baskets used was 40 cm and 30 cm, respectively.

Pot-in-pot refrigerator was prepared by putting smaller pots inside larger pots leaving the space of 2 - 3cm between the pots. The larger pot was previously filled with riverbed sand to a height that placed the smaller pot in same height with the larger pot. The space between the pots was also filled with riverbed sand leaving a small gap at the top. Water was poured into the sand until it was completely saturated and unable to take more water. A soaked white cloth was placed over the top of inner pot to cover the opening completely (SCI, 2016). Three botanical preservatives used were wood ash from shea butter tree (*Vitellaria paradoxa*), sawdust from African mahogany (*Khaya ivorensis*) and rice (*Oryza sativa*) straw. All the botanical preservatives were pulverized.

Each botanical and fruits from each variety were mixed in ratio 1:2 proportion which is equivalent to 1.75 kg of botanical to 3.5 kg of fruits. The tomato fruits in control experiments were not treated with botanical preservatives. The experimental set up for each variety is described as follows: VPCA (Variety + Plastic crate + Ash), VPCR (Variety + Plastic crate + Rice Straw), VPCS (Variety + Plastic crate + Sawdust), VPCC (Variety + Plastic crate + Control), VPPA (Variety + Pot-in-pot + Ash), VPPR (Variety + Pot-in-pot + Rice Straw), VPPS(Variety + Pot-in-pot + Sawdust), VPPC (Variety + Pot-in-pot + Control), VRBA (Variety + Raffia Basket + Ash), VRBR (Variety + Raffia Basket + Rice Straw), VRBS (Variety + Raffia Basket + Sawdust) and VRBC (Yoruba Variety + Raffia Basket + Control).The experiment was conducted at room temperature. Each set up was carried out in triplicate. The temperature of each setup was measured three times (morning, afternoon and evening) using a laboratory thermometer (Uniscope).

Determination of shelf life and weight loss of tomato during storage

Shelf life of sampled fruits was determinedwhen more than 50% of fruits symptomatically displayed shrinkage or sunken lesion (fruit rot) (Rao *et al*., 2011).

At 4 days interval, the weights of the samples were recorded. The percentage weight loss was determined using the formula below.

$$\text{Percentage weight loss} = \frac{\text{W1} - \text{W2} \quad \times 100}{\text{W1 -}}$$

Where, W1 = Initial weight and W2 = Final weight

Determination of effects of storage methods on proximate composition of tomato fruits

Proximate analysis was carried out to evaluate percentages of moisture, ash, protein, fiber, crude fat and carbohydrate after 20 days. Moisture content was determined by estimating the sample weight loss when dried to a constant weight in an oven at 65^{o}C for 36 hours (Mohammed *et al.,* 2017). Extraction method of AOAC (2000) was used to analyze crude fat. The method of Shahnawaz *et al*. (2009) was adopted to determine crude fiber using defatted sample. Crude protein was analyzed by Kjeldahl method (AOAC, 2000). Carbohydrate content of each sample was determined by difference as described by Ooi *et al*. (2012).

Data analysis

All data were analyzed using Statistical Package for Social Science (SPSS), version 16.00 software. One-way Analysis of Variance (ANOVA) was used to determine the differences within the variety. The level of significance used was $p< 0.05$. Where F ratio was significant, means were separated using Duncan Multiple Range Test (DMRT). Univariate analysis of variation (under General Linear Model) was used to determine the interactions among the fixed factors (variety, storage and preservatives).

RESULTS

Shelf life of tomato fruits

Temperature changes were observed in each storage structure containing tomato fruits and with botanical preservatives. The average temperature in plastic crates, pot-in-potrefrigerator and raffia baskets were 26.0^{o}C, 19.5^{o}C and 23.9^{o}C respectively.In Hausa variety of tomato fruits, the longest shelf life (20 days) was observed in the fruits stored in pot-in-pot refrigerator without treatment and the shortest (15 days) wasfound in ash treated fruits stored in both plastic crate and raffia basket.The longest shelf life of Yoruba variety fruit was 19days and this was observed in the fruits stored in pot-in-pot refrigerator without treatment, followed by those treated with sawdust in the same storage structure. Tropimech and Roma VF varieties had the longest shelf life of 17 and 16 days respectivelyin pot-in-pot refrigerator with sawdust. Among all the storage structures used, pot-in-pot refrigerator was the best as it enhanced the shelf life of all varieties used (Table 1).

Percentage weight loss was observed in all the fruits during storage. Pot-in-pot refrigerator was better than both plastic crate and raffia basket in terms of minimization of weight loss of the fruits (Table 2). Hausa variety had significantly highest percentage weight loss compared to other varieties. Also, raffia baskets increased weight loss significantly more than plastic crates and pot-in-pot refrigerator. Reference to botanical treatments, no significant difference in fresh weight loss was observed except those stored with ash. All possible forms of interaction of factors were significant (Table 3).

Proximate analysis of tomato fruits

Fruits of Tropimech and Roma VF varieties showed higher values of all the parameters when compared with the two local varieties (Hausa and Yoruba). Roma VF had significantly higher values of ash, fibre, lipid and carbohydrate while Tropimech showed higher values of moisture and protein. The results indicated that the use of raffia basket promoted higher values of moisture and lipid with a concomitant reduction in all other proximate composition (Table 4).

With respect to botanicals, significant differences were recorded in all the parameters except for ash. Storage with sawdust significantly enhanced the lipid, protein and carbohydrate of tomato over the other botanicals and the control. The control, however, showed significantly higher value of moisture and fibre contents when compared to other botanicals (Table 4).

Table 1: Shelf life (day) of four varieties of tomato fruits as influenced by storage structures and botanical preservatives.

Storage structure	Preservative	Shelf life (Days)			
		Hausa	Yoruba	Tropimech	Roma VF
Plastic crate	Ash	15	15	10	10
	Rice straw	17	15	13	12
	Sawdust	16	15	13	12
	Control	16	15	11	11
Pot-in-pot Refrigerator	Ash	16	14	12	13
	Rice straw	18	15	15	14
	Sawdust	19	17	17	16
	Control	20	19	15	16
Raffia basket	Ash	15	12	11	10
	Rice straw	16	14	13	12
	Sawdust	16	16	14	13
	Control	16	16	11	12

Table 2: Percentage weight loss of tomato fruits after 20 days of storage.

		HAUSA	YORUBA	Tropimech	Roma VF
Plastic Crate	PCA	37.56+3.20b	44.48±1.99a	25.81±1.81bc	22.76±1.25abc
	PCR	27.38±0.75c	28.40±2.46cd	24.95±1.30c	21.05±0.86abc
	PCS	27.38±0.71c	23.62±2.64d	25.27±1.41c	19.99±0.59c
	PCC	37.77±0.78b	24.15±1.96d	25.14±1.13c	24.05±1.31ab
Pot-in-pot Refrigerator	PPA	21.33±2.11cd	12.47±1.71e	13.59±1.78de	13.77±1.54d
	PPR	16.20±2.04d	13.07±1.61e	13.84±0.98de	12.71±1.46d
	PPS	19.12±1.83cd	12.44±0.60e	15.65±0.95d	11.70±1.25d
	PPC	14.35±1.84d	8.01±1.13e	10.53±0.84e	14.50±1.24d
Raffia Basket	RBA	36.42±4.21b	34.17±2.22bc	32.30±1.74a	22.94±1.47abc
	RBR	46.68±2.07a	32.88±4.40bc	29.63±1.41a	20.36±0.15bc
	RBS	41.94±3.30ab	38.62±2.47ab	31.82±1.08a	20.21±0.55c
	RBC	39.52±6.06ab	21.46±3.69d	30.57±1.18a	24.38±1.15a

Means followed by the same letter along the same column are not significantly different at $p < 0.05$. Treatments: PCA = Plastic Crate + Ash: PCR = Plastic Crate + Rice Straw; PCS = Plastic Crate + Sawdust; PCC = Plastic Crate + Control; PPA = Pot-in-pot + Ash; PPR = Pot-in-pot + Rice; Straw; PPS = Pot-in-pot + Sawdust; PPC = Pot-in-pot + Control; RBA = Raffia Basket + Ash; RBR = Raffia Basket + Rice Straw; RBS = Raffia Basket + Sawdust;RBC = Raffia Basket + Control

Table 3: Weight loss in tomato fruits and interaction among variety, storage structures and botanical preservatives.

Factor	Level of Factor	Weight loss (%)
Variety (V)	Hausa	30.47[a]
	Yoruba	24.48[b]
	Tropimech	23.26[b]
	Roma VF	19.04[c]
SE		0.58
Storage Structure (S)	Plastic crate	27.49[b]
	Pot-in-pot	13.96[c]
	Raffia basket	31.50[a]
SE		0.50
Botanical Treatment (B)	Ash	26.47a
	Rice straw	23.93[b]
	Sawdust	23.98[b]
	Control	22.87[b]
SE		0.58
V × S		*
V × B		*
S × B		*
V × S × B		*

Means followed by the same letter along the same column are not significantly different atp < 0.05. SE = Standard Error; * = Significant difference.

Table 4: Proximate compositions of stored tomato as influenced by variety, storage and botanicals.

Factor	Level of Factor	Moisture (%)	Ash (%)	Protein (%)	Fibre (%)	Lipid (%)	Carbohydrate (%)
Variety (V)	Hausa	93.70[b]	0.22[b]	0.11[bc]	0.15[b]	0.10[b]	5.72[b]
	Yoruba	94.22[a]	0.17[bc]	0.10[c]	0.14[b]	0.13ab	5.23[c]
	Tropimech	94.40[a]	0.14[c]	0.55[a]	1.14[a]	0.14[a]	3.65[d]
	Roma VF	91.91[c]	0.46[a]	0.15[b]	0.16[b]	0.10[b]	7.23[a]
SE		0.12	0.02	0.02	0.12	0.01	0.13
Storage Structure (S)	Plastic crate	93.25[b]	0.28[a]	0.25[a]	0.35[c]	0.16[a]	5.73[a]
	Pot-in-pot	93.39[b]	0.24[ab]	0.24[a]	0.45[a]	0.10[b]	5.59[a]
	Raffia basket	94.03a	0.22[b]	0.19[b]	0.40[b]	0.09[b]	5.07[b]
SE		0.11	0.02	0.01	0.01	0.01	0.11
Treatment(B)	Ash	93.73[b]	0.27[a]	0.22[ab]	0.38[bc]	0.10[b]	5.32[b]
	Rice straw	93.21[c]	0.22[a]	0.22[ab]	0.35[c]	0.10[b]	5.91[a]
	Sawdust	92.78[d]	0.24[a]	0.26[a]	0.41[b]	0.16[a]	6.15[a]
	Control	94.51[a]	0.25[a]	0.21[b]	0.45[a]	0.10[b]	4.48[c]
SE		0.12	0.02	0.02	0.01	0.01	0.13
V × S		*	*NS*	*	*	*	*
V × B		*NS*	*NS*	*NS*	*	*	*NS*
S × B		*NS*	*NS*	*	*	*	*
V × S × B		*	NS	*	*	*	*

Means followed by the same letter along the same column are not significantly different at p < 0.05; SE = Standard Error; *= Significant difference; *NS* = No significant difference.

The interaction between factors was also significant except for ash under variety by storage interaction; Moisture, ash, protein and carbohydrate contents under variety and treatment; and moisture and ash under storage and treatment interaction. The Interactions among all the three factors (V × S × T) were significantly different in all the parameters under proximate analysis except for ash (Table 4).

DISCUSSION

Hardenburg *et al*. (1986) mentioned that storage under relatively low temperature is the most efficient method to maintain the quality of most fruit and vegetables due to its effects on reducing respiration rate, transpiration, ethylene production, ripening, senescence, and rot development. It is generally agreed that mature green tomato can be stored for relatively long period at a temperature of 10–15°C and 85 – 95% relative humidity (Castro *et al*. 2005). It is interesting to note that in the present study the temperature in pot-in-pot refrigerator has enhanced the shelf-life of tomato fruits, recording the highest shelf life in the pot-in-pot refrigerator. This finding was supported by the results of Idah *et al.,* (2010) who reported that evaporative cooler system (pot-in-pot) was a promising storage mechanism that enhanced the shelf life of fruits and vegetables. However, with some careful modifications in pot-in-pot storage system, preserving fruits and vegetables will be more effective in the rural areas in Nigeria.

Chemical preservatives had previously used to preserve fruits. However, attention had been shifted because of their cumulative effects on the consumers. Nasrin *et al.* (2008) reported that chlorine-treated tomato fruits, stored in a perforated polyethylene bag at room temperature had a shelf life of 17 days which fell within the range of pot-in-pot storage system without preservative. The use of chlorine to preserve fruits had been banned in several European countries such as Germany, Belgium, Switzerland and The Netherlands due to the potential of forming carcinogenic chlorinated compounds in water (Ahmed *et al*, 2012). Tomato fruits treated with calcium carbide prolonged the storage life of tomato up to 18 days. However, the reported health implications include cancer, mouth ulcer, food poisoning and eye contact may result in permanent blindness (Asif, 2012). Botanical preservatives are effective in extending the storage life of fruits while inhibiting the growth of pathogens and increasing the physical quality of fruits (Draughon, 2004). The use of botanicals in lieu of chemicals as preservatives of fruits is efficacious and less toxic to human (Irokanulo *et al.,* 2015). These botanical preservatives are affordable and convenient for local farmers. According to Theu (2017), the action of sawdust to maintain the freshness and firmness of tomato for a long period is more effective than that of ash and this assertion supported the findings of the present study.

The results of the proximate analysis revealed that in all the varieties, moisture content was higher than other elements analyzed irrespective of storage methods and this was in agreement with the findings of Agbemafle *et al*. (2015) and Idah *et al*. (2010). The tomatoes could also be used as a potential source of water as water plays an indispensable role in the biochemical metabolism in the human body. Water not only hydrates the body but also serves as a thermoregulator and maintains the fluid balance (Popkin *et al*., 2010). The ash content of a food substance depicts the total crude minerals. Roma VF had the highest ash content (0.46%) and the value fall in the range of 0.47% - 0.98% as reported by Agbemafle *et al*. (2015). Plants accumulate these nutrients through absorption by roots in the medium of water, thus this action decreases especially in water-stressed plants (Akinci and Losel, 2012). The highest ash content in Roma VF may be as a result of its ability to absorb minerals from the soil (Agbemafle *et al*, 2015). The crude mineral concentrations in fruits are unchanged during the storage except when there are leakages from the fruits and also when they are not metabolized (Hui, 2006). The variances in ash content in each variety may be as a result of storage methods coupled with the influence of preservatives.

The range of protein content of all the varieties used was 0.07% – 0.92% lower than 1.0% - 1.1% as reported by USDA (2005). The differences may be as a result of varietal influence, environmental conditions and other agronomical practices during production (Agbemafle *et al*, 2015). The differences in protein content can also be attributed to botanicals which may have differential effects on the activities of cell wall enzymes such as α-galactosidase, β-galactosidase, β-mannosidase and β-glucosidase. These are also responsible for the rotting andsoftening of the fruit (Emadeldin *et al*., 2012). Fruits contain a low amount of protein but aged tissues such as overripe fruits usually have a higher amount of non-protein nitrogen (Vincent*et al*., 2009). Tropimech had highest percentage lipid, however, significantly lower than 0.20% as estimated by Idah *et al*. (2010). Agronomical activities during production may also account for dissimilarity. Fatty acids are very essential in physiological functions of human as they participate primarily to produce hormone-like substances which control blood pressure, blood clotting, the immune response, blood lipid levels and the inflammatory response (Vincent *et al*., 2009).

All varieties used contain a considerable amount of fiber in varying quantities. Onifade *et al*. (2013) revealed that the percentage crude fiber in Yoruba variety of tomato was 2.50%, comparatively higher than not only the similar variety in the present study but also other three varieties considered in this current study. The principal components of dietary fibers are lignin, cellulose, hemicelluloses, pectins, resistant starch and non-digestible oligosaccharides. The cell wall makes up to 1% to 2% of the fresh weight of fruits and cellulose constitutes about 33% of that amount (Vincent *et al*., 2009). Brummell (2006) reported that the quantity of cellulose fluctuates during fruit ripening. Dietary fibre is an indigestible component of food that enhance peristaltic movement of bowels. It prevents constipation as well as colon cancer (Terry *et al*., 2001). It modulates the function of the intestinal tractand characterized by low calories (Marlett *et al*., 2002). Carbohydrate is an essential nutrient in the body as it is the major energy source in the body. The amount of carbohydrate is second to moisture in all the varieties. It was observed that there is an interplay between the moisture and carbohydrate contents without the influence of storage methods. This assertion was supported by Idah *et al*. (2010) that the percentages moisture and carbohydrate are increasing and decreasing respectively as the storage period increasing.

CONCLUSION

The shelf-life of tomato fruits were depended on the varietal type, storage conditions and presence or absence of botanical preservatives. The storage period for tomato fruit was extended considerably when using pot-in-pot refrigerator. Sawdust and rice straw can also be considered as good biopreservatives. The variety, storage structure and botanical preservatives influenced all proximate parameters in tomatoes except ash content.

REFERNCES

Aborisade, A.T. (2003). Preliminary studies on the effect of sodium hypochlorite and wood ash on *Rhizopus stolonifer* and *Aspergillus niger*. *Nigerian Journal of Experimental and Applied Biology* **4**:197-201.

Agbemafle, R., Owusu-Sekyere, J.D. and Bart-Plange, A. (2015). Effect of deficit irrigation and storage on the nutritional composition of tomato *(Lycopersiconesculentum* Mill. cv. Pectomech). *Croatian Journal of Food Technology, Biotechnology and Nutrition* **10**(1-2): 59-65.

Ahmed, L., Martin-Diana, A.B., Rico, D., and Barry-Ryan, C. (2012). Extending the shelf -life of tomato using by-product from cheese industry. *The Journal of Food Processing and Preservation* **36**:141-15.

Akinci, S. and Losel, D.M. (2012). Plant Water-Stress Response and Mechanisms. In: Rahman, M. I., (ed): *Water Stress*. Intech, Shanghai. Pp.1-30.

Akomolafe, O.M. and Aborisade, A.T. (2007). Effects of simulated rural storage conditions on the quality of plantain (*Musa paradisiaca*) fruits. *International Journal of Agricultural Research* **2**(12):1037-1042.

Anju-kumari, Bhardwaj, M.L., Guleria, S.P.S. and Kumari, A. (1993). Influence of stage of harvest on shelf life and quality of tomato. *Horticulture Journal* **6**(2):89-92.

AOAC. (2000). *Official Method of Analysis* (17th Edition). Association of Official Analytical Chemists. Inc., Maryland, U.S.A.

Asif, M. (2012). Physico-chemical properties and toxic effects of fruits-ripening agent calcium carbide. *Annals of Tropical Medicine and Public Health* **5**:150-156.

Bachamann, J. and Earles, R. (2000). Postharvest Handling of Fruits and Vegetables. Horticulture Technical Note. Available at http://www.attra.org/attrapub/postharvest.html

Brummell, D.A. (2006). Cell wall disassembly in ripening fruit. *Functional Plant Biology* **33**:103-119.

Castro, L.R., Vigneault, C., Charles, M.T. and Cortez, L. A.B. (2005). Effect of cooling delay and cold-chain breakage on 'Santa Clara' tomato. *Journal of Food, Agriculture and Environment* **3**(1):49-54.

Dorais, M., Ehret, D.L. and Papadopoulos, A.P. (2008). Tomato (Solanum lycopersicum) health components: from the seed to the consumer. Phytochemistry Review **7**:231-250.

Draughon, F.A. (2004). Use of botanicals as biopreservatives in foods. *Food Technological Feat*. **58**:20- 28.

Emadeldin, H.E.K., Mathilde, C. and Mireille, F. (2012). Cell wall glycosidase activities and protein content variations during fruit development and ripening in three texture contrasted tomato cultivars. *Saudi Journal of Biological Science* **19**(3):277-283.

Gil, M.I., Aguayo, E. and Kader, A.A. (2006). Quality changes and nutrient retention in fresh-cut versus whole fruits during storage. Journal of Agricultural and. Food Chemistry, **54**:4284-4296.

Hardenburg, R.E., Warada, A.E. and Wang, C.V. (1986). The commercial storage of fruits, vegetables, florist and nursery stocks, agriculture. Handbook No 66, USDA Washington DC.

Hui, Y.H. (2006). *Handbook of Fruits and Fruit Processing*. Blackwell Publishing professional, Lowa, USA Pp. 36-37.

Idah, P.A., Musa, J.J. and Abdullahi, M. (2010). Effects of storage period on some nutritional properties of orange and tomato. *Assumption University Journal of Technology* **13**(3):181-185.

Irokanulo, E.O. Egbezien, I.L. and Owa, S.O. (2015). Use of *Moringa oleifera* in the Preservation of Fresh Tomatoes. *Journal of Agriculture and Veterinary Science* **8**(2):127-132.

Johnson, P.N.T. and Hodari-Okae, M.A. (1999). Influence of wood species on moist sawdust storage of tomatoes. *Tropical Science* **39**:214-219.

Kapsiya J., Gungula D.T., Tame V.T. and Bukar N. (2015). Effects of Storage Chemicals and Packaging Systems on Physicochemical Characteristics of Tomato (*Solanum lycopersicum* L.) Fruits. *AASCIT Journal of Bioscience* **1**(3):41-46.

Krumbein, A, Peters, P., Brückner, B. (2004). Flavour compounds and a quantitative descriptive analysis of tomatoes (*Lycopersicon esculentum*Mill.) of different cultivars in short-term storage. *Postharvest Biology and Technology* **32**:15-28.

Luthria, D.L., Mukhopadhyay, D. and Krizek, D.T. (2006). Content of total phenolics and phenolic acids in tomato (*Lycopersiconesculentum* Mill.) fruits as influenced by cultivar and solar UV radiation. *Journal of Food Composition Analysis* **19**:771-777.

Marlett, J.A., McBurney, M.I. andSlavin , J.L.(2002). Position of the American Dietetic Association health implications of dietary fiber. *Journal of the American Dietetic Association* **102**:993-1000.

Matthew, T. (2011). Post-Harvest Microbial Deterioration of Tomato (*Lycopersiconesculentum*) Fruits. *Report and Opinion* **3**(4):52-57.

Maul, F., Sargent, S. A, Sims, C. A, Baldwin, E. A, Balaban, M.O. and Huber, D.J. (2000). Tomato flavor and aroma quality as affected by storage temperature. *Journalof Food Science* **65**:1228-1237.

Mohammed, S.M., Abdurrahman, A.A. and Attahiru, M. (2017). Proximate analysis and total lycopene content of some tomato cultivars obtained from Kano State, Nigeria. *ChemSearch Journal* 8(1):64 - 69.

Nasrin, T.A.A., Molla, M.M., Alamgir Hossaen, M., Alam, M.S. and Yasmin, L. (2008). Effect of postharvest treatments on shelf life and quality of tomato. *Bangladesh Journal of Agricultural Research* **33**(3):579-585.

Nour, V., Trandafir, I. and Ionica, M.E. (2013). Antioxidant compounds, mineral content and antioxidant activity of several tomato cultivars grown in South-western Romania. Notulae Botanicae Horti Agrobotanici **41**(1):136-142

Olaniyi, J.O., Akanbi, W.B., Adejumo, T.A. and Akande, O.G. (2010). Growth, fruit yield and nutritional quality of tomato varieties. *African Journal of Food Science* **4**(6):398 - 402.

Olaniyi, J.O., Akanbi, W.B., Adejumo, T.A. and Akande, O.G. (2010). Growth, fruit yield and nutritional quality of tomato varieties. African Journal of Food Science **4**(6):398 - 402

Onifade, T.B., Aregbesola, O.A., Ige, M.T. and Ajayi, A. O. (2013). Some physical properties and thin layer drying characteristics of local varieties of tomatoes (*Lycopersiconlycopersicum*). *Agriculture and Biology Journal of North America* **4**(3):275-279.

Ooi, D., Iqbal, S. and Ismail, M. (2012). Proximate composition, nutritional attributes and mineralcomposition of *Peperomia pellucida* L. (Ketumpangan Air) grown in Malaysia. *Molecules* **17**: 11139-11145.

Passam, H.C.,Karapanos, I.C., Bebeli, P.J. and Savvas, D. (2007). A review of recent research on tomato nutrition, breeding and post-harvest technology with reference to fruit quality. *The European Journal of Plant Science and Biotechnology* **1**(1):1-21.

Peralta, I.E. and Spooner, D.M. (2007). History, origin and early cultivation of tomato (Solanaceae). In: Razdan, M. K., Mattoo, A. K. (eds). *Genetic Improvement of Solanaceous Crops*, Vol. 2. Enfield, USA. Science Publishers. Pp 1-27.

Popkin, B.M., D'Anci, K.E., Rosenberg, I.H. (2010). Water, hydration, and health. *Nutrition Review* **68**:439-458.

Rao, R., Gol, B. and Shah, K. (2011). Effect of postharvest treatments and storage temperatures on the quality and shelf life of sweet pepper. *Scientia Horticulturae* **132**:18-26.

Saeed, A.F.U., Khan, S.N., Sarwar, A. and Tahira, J.J. (2010). Effect of packing materials on storage of tomato. *Mycopath* **8**(2):85-89.

SCI (2016). Solar Cookers International. Available at solarcooking.wikia.com/wiki/Pot-in-pot cooler. Retrieved 25/01/2016.

Shahnawaz, M., Sheik, S.A. and Nizamani, S.M. (2009). Determination of nutritive values of Jamun fruit *(Eugenia jambolana)* products. *Pakistan Journal of Nutrition* **8**(8):1275-1280.

Shaun, R. and Ferris, B. (1997). Improving storage life of plantain and banana, IITA Research Guide, 61. 21p.

Srinivasa, P.C., Harish-Prashanth, K.V., Susheelamma, N.S., Ravi, R. and Tharanathan, R.N. (2006). Storage studies of tomato and bell pepper using eco-friendlyfilms. *Journal of the Science of Food and Agriculture* **86**:1216-1224.

Terry, P., Giovannucci, E., Michels , K.B., Bergkvist , L., Hansen , H., Holmberg, L., Wolk, A. (2001). Fruit, vegetables, dietary fiber and risk of colorectal cancer. *Journal of National Cancer Institute* **93**:525-533.

Theu, M.P.K.J. (2017). Use of locally available materials to increase the shelf life of ripe tomatoes. Available at www.cabi.org/gara/FullTextPDF/2008/20083327078.pdf. Retrieved 02/06/2017.

USDA. (2005). United Stages grades for fresh tomatoes. United States Department of Agriculture. Ag. Mtkg. Ser. Washington D. C. 10p.

Vincent, A.R., Manganaris, G.A., Sozzi, G.O. and Crisosto, C. H. (2009). Nutritional quality of fruits and vegetables. In Florkowski, W. J., Shewfelt, R. L., Brueckner, B. and Prussia, S. E. (editors). *Postharvest Handling: A Systems Approach*. Second Edition. Elsevier Inc. Academic Press.